Surface Chemistry Optimization for Emerging Health Care Technologies

The potential clinical applications for protein microarrays are well recognized however barriers to their development as a reliable measurement tool persist. Two major barriers include: (1) proteins tend to adsorb non-specifically to solid substrates, leading to less sensitivity and low signal to noise ratio, and (2) the complexity associated with protein orientation. NIST is developing technologies to overcome these two problems.

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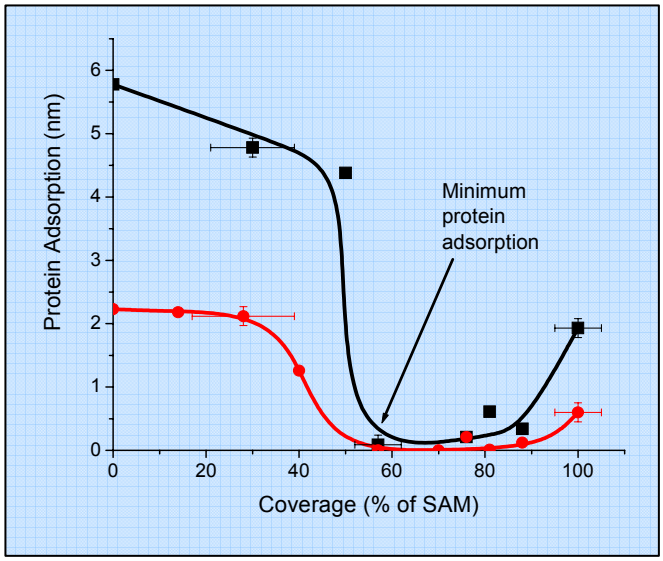
Limiting the adsorption of proteins and microorganisms remains a prominent problem to protein array development. This technical challenge also persists in other biotechnology areas (bioreactors, biosensors), healthcare (implants, contact lenses), tissue engineering, drug delivery, fundamental science (antibody studies, surfaces of viruses and bacteria), and commerce (clogging of cooling intakes, fouling of ship hulls). Because proteins have complex structures and activities, the immobilization chemistry has to be such that it preserves a protein's native state and with an orientation that is optimal for the protein-target interaction.

NIST began studying protein adsorption chemistry using surface plasmon resonance. We found that self-assembled monolayers of $HSCH_2CH_2CH_2O(CH_2CH_2O)_5CH_3$, covering ≈ 60% of the surface, achieve near-zero adsorption of macromolecules. The biological zero (of adsorption) is clearly defined from our protein adsorption as a function of oligomer coverage, as shown in the figure. Knowing the biological zero of adsorption permits both the extension of the dynamic range of all analytical interfaces and the neutralization/minimization of surface effects, which increase as nanostructures become smaller.

Most importantly, the relatively low surface coverage of optimal protein resistance suggests a general strategy for the preparation of numerous biologically relevant surfaces for subsequent binding of molecules tailored for specific interactions.

NIST is currently developing new materials that will sustain optimal coverage for protein resistance properties and improve the surface robustness.



Surface plasmon resonance adsorption data of fibrinogen (black) and bovine serum albumin (red) on polycrystalline gold coated with $HS(CH_2)_3O(CH_2CH_2O)_5CH_3$, from bare Au (0% coverage) to a complete, near-single-phase self-assembled monolayer (SAM) (100% coverage).

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